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Barriers to Using Models and Simulations (M&S) in Training Forums

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ABSTRACT

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What are the barriers to synchronous and asynchronous integration of live, virtual, and constructive (L-V-C), and classroom training and leader development?

Statement of desired condition:

A Corps headquarters conducts a Battle Command Training Program (BCTP)-like command post exercise (CPX). In the exercise, headquarters personnel command divisions that might be CPX -configured or might function in a more administrative capacity. The brigades of these divisions might be at a Combat Training Center (CTC), deployed to the Balkans, on the range, or in their containment areas, but all share a common, real-time operating picture. This scenario supports system simulators across the Army, and also is the backdrop for tabletop exercises and leader development vignettes in the classroom. Reserve and National Guard units participate as equal partners via an extensive learning infrastructure and Battle Projection Centers.

As an element of the overall campaign, increased unrest in another theater might threaten peacekeeping forces while a catastrophic event occurs somewhere in the continental United States (CONUS), with all the constructive and virtual simulations linked in real time.

Where the training objectives of one element threaten the training success of another element, asynchronous linkage should be used so that one set of events feeds but does not govern the outcome of another.

Supporting facts:

Live training is prohibitively expensive and logistically impossible at higher levels.

Many high-quality simulations exist, yet few are linked. Defense simulations are typically not connected to or compatible with those in the civilian sector.

Command and control in the 21st century will consistently be multidimensional and split-based. There will always be more factors to consider than an identifiable, linear opposing force (OPFOR).

The theater is now global, and the CONUS is the rear area.

Static courseware will always be outdated. Today's leaders must be adaptive and the means the Army uses to develop them must be adaptive, as well.

TABLE OF CONTENTS

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LIST OF TABLES

BARRIERS TO USING MODELS AND SIMULATIONS (M&S) IN TRAINING FORUMS

Have you ever wondered why models and simulations (M&S) are used in the Army? This report provides readers with some insight into the reasons, and also examines the difficulties in using M&S when one scenario(s) determines the outcome of another scenarios(s) when it should not. Where the training objectives of one scenario threaten the training success of another, it is necessary to resort to asynchronous (nonsimultaneous) linkage so that one set of events feeds but does not govern the outcome of the other.

This report addresses the following questions:

1. How did the Army arrive at the current stage of M&S development?
2. What is asynchronous linkage and why does the Army need it?
3. How should the Army train leadership?
4. What new barriers has new technology brought to the use of M&S in training events?
5. What changes are needed to ensure M&S success?

I. HOW DID THE ARMY ARRIVE AT THE CURRENT STAGE OF M&S DEVELOPMENT?

The Army has a long history of using M&S. The Army trains at all levels and across the world using M&S. Analytical results derived using M&S are excellent tools to use in making warfighting decisions. The Army uses M&S to improve the quality of its acquisition process and the products it provides to soldiers. M&S are the modern-day war-gaming tools.

EARLY WAR-GAMING

The first use of war-gaming is credited to Sun Tzu. He created the game known as "Wei Hai" about 1000 B.C. Wei Hai used a specially designed abstract playing surface upon which each of the contestants maneuvered armies of colored stones. Victory went not to the player who could destroy his opponent head-on, but to the first player who could outflank his enemy. (14, pg 17)

During this period, war-gaming systems were also appearing and becoming popular in other parts of the world. In India, a four-sided board game known as "Chaturanga" developed in which the outcome of "Maneuvers" was determined by rolling dice. The beginning of modern-day chess is also attributed to this period. Chess-like games require the players to focus on a well-defined objective and to evaluate the abilities of their own and their opponent's force. They must analyze the strengths and weaknesses of various dispositions, and devise strategies and tactics to overcome the enemy's strength and compensate for their own weaknesses.

In the mid-17th century, the recognition that these types of games were too abstract to be useful as a tool for teaching the finer points of the art of war led to variations and complications of the basic chess model to add more and more military detail. The first new game was the "Kings Game" or "Koenigspiel," invented in Germany in 1664. (14, page 17) These games introduced some of the basic underlying principles and characteristics of modern M&S (Table 1).

- Aggregation using a single player/piece to represent units or collections of soldiers/forces
- Terrain representation (multicolor/grid-based)
- Rules for movements and conflict resolution
- War described in terms of basic concepts and rules

TABLE 1 UNDERLYING PRINCIPLES AND CHARACTERISTICS OF MODERN-DAY M&S SYSTEMS

MORE SOPHISTICATED WAR-GAMES OF THE EARLY 1800S

Early in the 1800s, Prussian war counselor Baron Von Reisswitz replaced the game board of war chess with a sand table in which actual terrain could be modeled in relief. The playing pieces were made of wood cut to scale to represent military units. Symbols representing the different units were pasted to the blocks. (14, pg 23) Von Reisswitz's rules dealt only with movement of the forces; results of engagements were worked out through discussion and debate among the various players and observers.

In 1824, von Reisswitz's son upgraded the game, replacing the sand table with detailed topographic maps drawn to 1:8000 scale. He quantified the effects of combat so that results of engagements were calculated rather than discussed. This implemented a detailed set of rules covering virtually every contingency of operations of units up to the size of divisions and corps. These rules were finally published in 1824 as "Instructions for the Representation of Tactical Maneuvers under the Guise of a Wargame" (Table 2). (14, pg 25)

- Scaled icons/blocks representing units and force frontages
- Time/distance considerations during moves
- Calculated effects of combat/engagements
- Rules for a wider range of contingencies/scenarios
- Codifying military experience and effects of combat verification, validation, and accreditation
- The need to balance between realism and playability

TABLE 2 INSTRUCTIONS FOR TACTICAL MANEUVERS

W.R. Livermore is credited with introducing German-style war-gaming to the United States by publishing "The American Kriegspiel" in 1879. Livermore's system was a derivative of rigid Kriegspiel. The blocks representing combat units were made of porcelain, metal, or wood. They were red and blue, but various other colors were used to distinguish different types of combat arms and specialized units. The playing pieces were cut to scale and could be used to represent a regiment of infantry, a company, or skirmishes depending on the scale of the map. The U.S. version included more sophisticated unit/force symbols, tracking of consumables (logistics), the setting of player-piece indices for direction and speed of movement, volume of fire, and an initial attempt to account for human attrition factors, (time and fatigue). The overhead (time and cost) of setting up and running war games increased as the complexity continued to increase. The U.S. Naval War College codified U.S. Kriegspiel in 1884 and in 1887 fully integrated war-gaming into the curriculum for all attending officers.

TECHNOLOGY DRIVES M&S

Two particular areas provided the main impetus to the M&S community—computer technology and the development of simulator devices. On the technology side, several major breakthroughs occurred that would have a direct effect on the advancement of M&S as a major component of Army doctrinal development, training, and operations (Table 3).

- First commercially available computer (Universal Automated Computer [UNIVAC-1]) (1952)
- First silicon transistor developed by Texas Instruments (1955)
- Integrated circuit developed (1957)
- Defense Advanced Research Projects Agency (DARPA) established (1958)
- First mini-computer PDP (1959)

TABLE 3 BREAKTHROUGHS IN ARMY DOCTRINAL DEVELOPMENT

The Secretaries of the Army and the Navy signed a Memorandum of Agreement in 1951 to cooperate in the development of training devices and simulators. The Navy activity was the Special Devices Center, and the Army's was the Army Participation Group. Technology advances continued in the 1960s with the development of the IBM 7000 series of mini-computers and additional enhancements in the area of "silicon chip" technologies and micro-circuitry (Table 4). The most significant technology initiative was the development and implementation of the Advanced Research Projects Agency Network (ARPANET) in 1969. This wide area network was funded by the Department of Defense (DoD) as an experimental project to support the research, development, and testing of network technologies. The original ARPANET connected several host computers at four separate universities, allowing them to share resources and information. ARPANET was the precursor to what today is the Internet.

- First appearance of line-of-sight (LOS) algorithms (1961)
- First digitized terrain databases and visual replications within an M&S environment (1963)
- CARMONETTE Analytical Model used in cost and operational effectiveness analysis in support of the Army's material acquisition process, feasibility studies of alternative weapons systems, sensors, and tactics in multiple tactical and operational scenarios (1961)

TABLE 4 ADVANCES IN THE 1960S

ADVANCES IN THE 1970S AND 1980S

In the 1970s and 1980s, as in the 1960s, the most significant activities that affected the Army's and other services' M&S development and implementation revolved around computer technology enhancements. With Intel's development of the microprocessor in 1971, the M&S industry surged forward, providing more and more sophisticated and capable war-gaming systems and simulator devices. Throughout the 1970s and the 1980s, these technologies and the associated advances in the models, simulations, and simulator arenas continued to provide key enablers to the military training community (Table 5 and Table 6).

- Computer-to-computer packet networking/data packaging (1974)
- Microsoft and Xerox formed (1976)
- Ethernet, Windows, icons, mouse vs. keyboard input/output (1976)
- Army Training Support Center (ATSC) stood up as the major controlling agency for Army training aides, devices, simulations, and simulators (TADSS)
- Silicon Graphics formed/IBM personal computer (PC) appears (1982)
- Rand Strategy Assessment System (RSAS) initiates LOTUS 123 (1983)
- Warrior Preparation Center (WPC) created in Ramstein, FRG (1983)

TABLE 5 NEW TECHNOLOGIES IN THE 1970S AND 1980S

- Navy creates Top Gun program and devices (1971)
- DIVWAG Model (1974)
- USAF creates/begins Red Flag series of computer-based, war-gaming experiments and exercises combining live and virtual environments (1974)/Blue Flag (1984)
- Army begins transitioning of manual board game-based simulations to full-scale, computer-assisted, computer-based environments (Dunn-Kempf, Pegasus, First Battle)
- Army Tactical Training Battle Simulations System (ARTBASS) model/system fielded
- JANUS model developed (1974)
- UH-1H, CH-47, and AH-1 Cobra flight simulators fielded
- First-generation multiple integrated laser engagement system (MILES) system/components fielded
- Conduct of fire trainer (COFT)/unit conduct of fire trainer (UCOFT) developed and fielded to support M1 Tank, (1980)
- Training and Doctrine Command (TRADOC) schoolhouses develop simulators and specific military occupational specialty (MOS) skills trainer
- First field training exercise (FTX) driven by a simulation (JESS/1987)
- Army adopts Joint Exercise Simulation System (JESS)/Corps Battle Simulation (CBS) as standard simulation for corps- and division-level training (1988)

TABLE 6 ADVANCES IN THE 1970S AND 1980S

The networking technologies developed during this period are the most significant advances for the M&S community. The original ARPANET expanded many times over and, by 1978, had changed from functioning primarily as an academic, information-sharing architecture to being able to provide and support wide area networking for computer-based simulations/war-gaming exercises. The simulation network (SIMNET) was initiated in 1982 as a combined Army/Advanced Rescue Projects Agency (ARPA) initiative. SIMNET produced the first truly distributed simulation environment, becoming the prototype for largescale, computer-based training simulations within the DoD. The Defense Simulation Internet (DSI) was implemented to support the expected need and projected usage of war games and simulations/simulators. The DSI architecture was designed to provide a high-capacity, high-speed backbone networked to multiple user sites or nodes throughout the U.S. The DSI also provided connectivity to overseas data communications architectures that would allow networking to Army and U.S. M&S sites and centers in Europe and Korea.

CONTINUED DEVELOPMENT IN THE 1990S

The M&S-related advances in the 1980s and 1990s continued, with the addition of new models, simulation systems, simulators, and interoperability standards due to increasing capabilities in PC processing power, data storage techniques, data formatting and packaging techniques, and the introduction of new and more efficient networking technologies and data-sharing architectures. Managing the configuration of existing systems became more formalized and began to better integrate user requirements and expectations. The Defense Model & Simulations Office (DMSO) was formed to provide a DoD-level management structure on M&S programs. The Executive Council for Models and Simulations (EXCIMS), consisting of representatives from all the services, and the research and development (R&D) community, were also created to provide general, officer-level oversight and guidance. The Defense Science Board (DSB) in 1991 formally codified M&S systems into the present M&S domains: live, virtual, and constructive (L-V-C). The DoD M&S organizational hierarchy, strategic objectives, goals, and requirements were further defined in 1994 by DoD 5000.59P: *DoD M&S Master Plan.*

Significant advances in bringing together multiple systems and models within the constructive domain were achieved in the early 1990s through the implementation of the Aggregate-Level Simulation Protocol (ALSP) Confederation, providing all-service system representation within a single exercise environment (Table 7). This development greatly enhanced battle staff training at the corps and division levels. The Combined Arms Tactical Trainer (CATT) family of simulators achieved major advances in linking together multiple simulator platforms in a single exercise. Semi Automated Forces (SAF) models also began to appear within the virtual domain. The realization of the need to bring together not only multiple systems within a single domain (i.e., constructive simulations or virtual simulators), but also the need for federation of L-V-C systems became a reality with the introduction of Distributed Interactive Simulation (DIS) standards. Early Synthetic Theater of War (STOW) events (Atlantic Resolve 1994 and Prairie Warrior 1995) demonstrated cross-domain interoperability between the brigade/battalion battle simulation (BBS) model (constructive), SIMNET (virtual), and the modular, semi-automated forces (ModSAF) environments.

- First inter-service linking of models (1992) via ALSP (CBS + air warfare simulation [AWSIM])
- STOW-E/STOW-A achieves linking of SIMNET/AVNET, BBS, and ModSAF (1994)
- High-level architecture (HLA) concept developed as the way for creating truly interoperable M&S federations approved as the standard technical architecture for all DoD simulations (1996)

TABLE 7 ADVANCES IN THE 1990S

M&S IN THE 21ST CENTURY

"Information Operations" and "Information Dominance" are key warfighting concepts for the Army of the 21st century. M&S systems and environments must be able to accurately replicate the battlefield and the battlefield systems that commanders, staffs, and individual soldiers will use, or are already using, to conduct military operations and make key decisions across the world. A key capability that M&S must achieve is full interoperability with the emerging family of command, control, communication, computers, and intelligence (C4I) systems and components. The concept of simulation-stimulation (simulations providing high fidelity, real-time stimulus to go to war command and control [C2] systems and devices) is driving much of the efforts within the M&S development community as it continues to develop and enhance M&S toolboxes.

L-V-C M&S environments, fully integrated and interoperable with war-fighting C4I systems, will be the standard for the 21st century. High-level architecture (HLA) will become the standard for cross domain interoperability, as described here:

> The High Level Architecture (HLA) is general purpose architecture for simulation reuse and interoperability. The HLA was developed under the leadership of the Defense Modeling and Simulation Office (DMSO) to support reuse and interoperability across the large numbers of different types of simulations developed and maintained by the DoD. The HLA Baseline Definition was completed on August 21, 1996. It was approved by the Under Secretary of Defense for Acquisition and Technology (USD [A&T]) as the standard technical architecture for all DoD simulations on September 10, 1996. The HLA was adopted as the Facility for Distributed Simulation Systems 1.0 by the Object Management Group (OMG) in November 1998. The HLA was approved as an open standard through the Institute of Electrical and Electronic Engineers (IEEE—IEEE Standard 151—in September 2000. The HLA MOA was signed and approved in Nov. 2000. (7, no pg)

The approval of the HLA cited in the extract above required all future simulations to follow the guidelines dictated by HLA.

The Close Combat Tactical Trainer (CCTT) family will reach maturity and provide a high-resolution, virtual training environment. Joint Simulation and Integrated Modeling System (JSIMS)/Warfighters' Simulation (WARSIM) will become the single constructive environment needed to support Joint Task Force (JTF), and corps- and division-level training. One semi-automated force (OneSAF), combined with CCTT will provide full M&S based training capability at the levels of brigade and below. All of these M&S tools will be developed to be fully interoperable, modular, and reusable. M&S will provide the fidelity and realism needed to maintain the operational readiness of the soldiers, units, commanders, and battle staffs of the 21st century and beyond.

II. WHAT IS ASYNCHRONOUS LINKAGE AND WHY DOES THE ARMY NEED IT?

Asynchronous replicated databases have been developed to provide continuous access to data despite intermittent connectivity. The entire database is replicated to each network node, and “reads” and “writes” are performed on local copies rather than on a centralized master database. Updates made at nodes are propagated to other nodes asynchronously. Most major commercial database vendors support this method of asynchronous replication. (3, pg 1)

Asynchronous simulations are used to link live units on the ground to virtual units in an exercise. This can be done in the same geographical location or over multiple locations. The key is to achieve connectivity of all C4I and simulations system belonging to all participants.

EXAMPLE OF ASYNCHRONOUS LINKAGE

The following is an example of true asynchronous linkage:

The 1st Cavalry Division performs "Battle Focused Training" with units in four geographic locations, one of which is in the Balkans. The division also interacts with Navy, Marine Corps, and Air Force units; as well as with a German infantry brigade. These forces are at widely distributed locations; CONUS, OCONUS, and afloat.

The division commander is located at the National Training Center (NTC) in his tactical command post. MCS displays all divisional forces whether live, virtual, or constructive. Northern Command (NORTHCOM) serves as the Joint Task Force (JTF) headquarters and uses a constructive simulation to represent flank units. The 1st Brigade is live in the NTC "box." The aviation section of the division cavalry squadron is screening the division left flank in flight simulators.

Simultaneously, the ground section of the division cavalry squadron screens the division left flank on a local training area. Two of 2d Brigade's maneuver battalions conduct operations virtually in CCTT, while the brigade Tactical Operations Center (TOC) commands operations from a field location. The Division-Main, in the Fort Hood Home Station Operations Center (HSOC), is planning future operations based on the Computer Generated Forces (CGF) OPFOR.

Officers and NCOs attending courses at the Infantry School at Fort Benning serve as the third battalion of the 2d Brigade. One company of Basic NCO Course (BNCOC) students is live on the Digital

Multipurpose Range Complex (DMPRC). A company of Infantry Officer Basic Course (IOBC) and Advanced NCO Course (ANCOC) students is training on the CCTT. A group of Infantry Officer Advanced Course (IOAC) students under the guidance of pre-command course participantsis constructive in the HSOC serving as the battalion Tactical Operations Center (TOC).

The 3rd Brigade is deployed in support of the Peace Keeping mission in Bosnia. One battalion is performing real-world missions. A second battalion is conducting a field training exercise (FTX) in a local training area. The third battalion is training virtually in the CCTT. The brigade TOC is in the HSOC concurrently commanding the real-world and training activities.

An Air Force tactical fighter wing is also participating in this training exercise. The Wing HQ is in the HSOC at Eglin Air Force Base interacting with a constructive simulation. Two fighter squadrons are attacking air and ground targets virtually in Flight Simulators.

A Marine Expeditionary Brigade (MEB) is afloat in the Mediterranean Sea. The MEB CP is rehearsing its plan in a constructive environment. The CH-46 squadron is rehearsing its air assault mission in a flight simulator.

Similarly, a Carrier Battle Group (CBG) is afloat in the North Sea. The CBG staff is interacting with a constructive simulation. The F/A-18 squadron is attacking air and ground targets virtually in a Flight Simulator.

A German brigade is participating in this event in Germany. An infantry battalion conducts live fire training in a local training area. The remainder of the brigade is generated in a constructive simulation. The brigade TOC operates in a mobile HSOC and interacts with a constructive simulation while commanding the actions of the live battalion.

L-V-C

The operational concept for the L-V-C describes the Army's vision to create and seamlessly integrate embedded training, instrumentation, simulations, and simulators and develop the interoperability standards, requirements, and commonality of legacy, interim, joint, and objective forces systems within the construct of the Training Support System (TSS). The L-V-C will approximate and embed into Objective Force Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems and Future Combat Systems (FCS) platforms, and also will interoperate with legacy, interim, and joint force systems.

The L-V-C will support training and mission planning, preparation, and rehearsal at the home station, institutions, CTC, and while deployed. It must also sustain individual and collective skills. Within the L-V-C, disparate units in different geographical locations *(as described in the example above)* can train as a force package prior to deployment. The L-V-C must also support training a mix of legacy, interim, objective, and joint forces that may work together under a single command. The L-V-C will have seamless access to task databases, training support packages, and equipment-specific training data within the TSS. This system of systems (SoS) supports strategic, operational, and tactical mission-driven scenarios developed from the Universal Joint Task List (UJTL), Army Universal Task List (AUTL), Joint Interoperability Task List (JITL), and unit's Mission Essential Task List (METL). (8, pg 15–17)

Synchronization of the combined arms team in deep, close, and near-battle scenarios remains the cornerstone of success. Because situation awareness (SA) provides overwhelming leverage to synchronization, and because synchronization is most operative at battalion/brigade level, it is the level of highest SA payoff for the maneuver forces. This is regardless of the strategic setting or dimension of war that is being addressed. (9, pg 18)

III. HOW SHOULD THE ARMY TRAIN LEADERSHIP?

Enhanced situation awareness (SA) is one of the primary goals of the Objective Force and beyond. It is a critical axis of advance for the revolution in military affairs. The focus of training leaders in situation awareness is upon the warfighter, not the digital architectures. "Decision makers in the Army are technically deficient and we need to train them to technical proficiency," observed Dennis Chrisman, a training specialist in the National Simulation Center, commenting on this situation.[2] Technologies that enhance SA must be designed to aid leaders and soldiers in doing their jobs on the battlefield, i.e., enhancing their battle-command, decision-making, and soldiering skills. (9, pg v)

SA refers to the ability of a person to develop an adaptive internal model of his or her environment. Good SA implies that the person can use that information to solve problems or otherwise interact effectively with the environment. As the Army continues to integrate advanced technologies into its force, SA is increasingly being recognized as a determining factor in battle outcome. "Decision makers must know capability before the decision is made and alternatives to making those decisions," pointed out Fort Leavenworth telecommunications manager Dick Brown.[3] "We must define the information needed and have the ability to control it," commented Greg Beach, marketing and business development director at Anteon.[4]

Most of the focus in digitization has been on materiel—hardware, communications protocols, and bandwidth—and on doctrine and organizational structures. Digitization also involves training, leader development, and resolution of soldier issues. (9, pg vii)

The Army must develop and/or modify training environments to train soldiers specifically for situational dominance. SA allows the Army to apply the full effects of the battle operating system (BOS) to defeat the enemy on the Army's timeframe and at the place of the Army's choosing. Training should provide repeated practice, performance feedback, and increasingly difficult, complex situations. The training goal should not be task proficiency, but "hyper-proficient" individuals and teams who can fully exploit available SA technologies. Also, leaders must be specifically trained in how to use the new SA information to make better decisions. Deferring decisions until "perfect" SA is available should be avoided. (9, pg ix)

THREATS SOLDIERS FACE

The threats soldiers face include information overload and its resultant fatigue, over-control of subordinates, vulnerability to countermeasures, unequal/incompatible technology among coalition forces, and failure to adapt organizational structure to new doctrine and procedures. One SA measurement framework includes three levels of SA with measurement mechanisms for each level. The first level is *perception* of elements in the current situation. This includes each soldier knowing his or her location, friendly soldiers, and enemy location, as well as knowing the terrain and obstacles, mission details, and commander's intent. The second level is *comprehension* of the current situation, which includes understanding friendly and enemy strengths and weaknesses, the status of the mission, deviations from the expected, and timeliness/confidence in information. The third level is *projection* of the future, which includes projection of friendly and enemy activities. (9, pg x)

USING DIGITAL CAPABILITIES TO TRAIN FOR SITUATIONAL DOMINANCE

How does the Army train soldiers in situational dominance? If the Army is truly going to make a half-evolutionary and half-revolutionary change toward enhanced SA, it will have to take a serious look at the training system. As new systems are introduced, it will not be sufficient to squeeze new system training into existing programs of instruction and unit training plans. There should be a comprehensive re-examination of the full range of knowledge and skills needed in the information age and for effective training methods. New training environments and systems will need to be developed for both institutional and unit training that specifically develop SA decision-making skills. This will require the redesign of tactical engagement simulations (TES), including L-V-C simulations, with appropriate training support packages for each echelon. The Army must fit training to the situation through various levels of fidelity in simulations, from full immersion to execution-based training.

TRAINING LEADERS

How does the Army develop leaders who can fully exploit emerging digital and SA systems and at the same time demonstrate the full range of skills known to be necessary for good Army leadership? (9, pg 4) How digitized should the Army expect leaders to be? Will it be enough to train supporting staff trained to assist the leader in decision-making? The basic point is that as the Army moves toward greater digitization, it will probably have to consider a number of new *second- and third-order* leadership effects. For example, the Army may doctrinally claim that there will be decentralized, nonlinear decision making. Getting NCO and officer leaders to truly delegate (or conversely fully assume) decision-making responsibilities does, however, represent a significant cultural change in the Army and may be difficult to effect. (9, pg 5) Some believe that to meet these requirements the personnel system will need to attract and retain a different population of soldiers than is in the Army today. (9, pg 6)

DESIGNING C4ISR SYSTEMS

It is also important for C4ISR systems to be designed with the soldier in mind. In the past, much of the emphasis regarding human factors has been on the physical fit between the soldier and a piece of equipment or crew station. In the future, human factors issues will also focus on the fit between the soldier and information; i.e., is the information presented in such a way that the soldier makes good decisions based on that information? (9, pg 6)

The integration of SA technology into the digitized Army may provide an overwhelming advantage if properly employed. The underlying goal should be to build a system that focuses efforts on killing enemy units, while protecting friendly forces against enemy actions and fratricide. Care must be taken to ensure that the technical systems used are sustainable, affordable, redundant, self-healing, and have multiple applications. (9, pg 17)

PRIORITIES: COMPETENCE AND CONFIDENCE

The first priority for the individual combatant and small unit leader is *competence,* which means being trained to be tactically and technically proficient. Once this is achieved, the soldier and leader must then gain the second priority, *confidence.* Soldiers and junior leaders must have confidence in their leaders, their equipment, and themselves to be able to perform the tasks that the average soldier would be incapable of performing. (9, pg 45)

The objective in design and training is to provide soldiers with the best information and tools possible so that they has the information needed to hit the right target at the right time. How close the Army comes to providing soldiers with the "ideal" or perfect knowledge is one measure of how well a particular system design functions. (9 pg 56) In addition, it must be pointed out that just getting needed information to the system is not enough. The information must be presented through the interface in a form that allows it to be quickly read (or heard) and comprehended. If the system requires soldiers to dig through menus and hunt for needed information, they may not achieve the SA required, particularly in stressful and time pressured battlefield-conditions. For this reason, the SA that the soldier possesses, not that the system possesses, must be evaluated as the measure of the system's merit. (9, pg 59)

IV. WITH NEW TECHNOLOGY, NEW BARRIERS TO M&S ARISE

The Army is an information-driven organization. As a result, information technology serves as a combat multiplier when knowledge is merged with workflows. Technology can permit multi-echelon training using three interoperable and integrated environments; live, virtual, and constructive (L-V-C). Using technology, training will include joint, interagency, and multi-national (JIM) forces. Technology will tailor training to a unique geographical area based on databases of strategic knowledge.

INTEROPERABILITY NEEDED

The key to this complex interaction is the interoperability of applied technology. Established standards, protocols, language, and procedures are required for interoperability and the development of L-V-C simulations, models, and devices. Currently there is a lack of integration, and there is not a unifying force of interoperability among the various military services, agencies, and the international allies of the U.S. As a result, future L-V-C training will suffer due to the widespread fragmentation of various digital systems that lack interoperability. It is imperative that a common operational platform be developed to provide interoperability to produce a common operating picture. This includes a common operating system (OS), standards, protocols, and user interface to achieve total interoperability and integration. (8, pg ii) LTC Kanzenbach and Dennis Chrisman agree the missing key is to insist on a common operating system.[5] [6] "Contractors like to claim proprietary right—and do not like writing to accepted protocols," said Chrisman. [7]

PEOC3T defines software users outside of the fielded unit as "nonstandard," isolating emerging training requirements and, therefore, requiring MACOMs to purchase training software and version upgrades. The Army has not directed software developers and procurers to negotiate enterprise license agreements at an Army level to take the funding issue off the user and accommodate software evolution. No Army-wide process exists to address interoperability issues that result from the fielding of different system software versions to different units. *Experienced trainers and other Army personnel must insist that* *software standardization upgrades be fielded simultaneously and that everyone uses the same version to ensure interoperability.* [8] [9] [10]

Software blocking will provide for the systematic distribution of software upgrades to both units and the institutional training base to minimize the impact on Army readiness. Program managers (PMs) are responsible for developing and providing new equipment training (NET). In some cases, PMs are not providing products that units and the proponent schools need. Fort Hood, Fort Lewis, and the proponent schools are developing programs of instruction (POIs) and TSPs because these packages were inadequate or not delivered in a timely manner. "It's tough keeping current with C4I systems and who will pay to sustain the currency of boxes," observed Tami Griffith, PEO-STRI project director. [11] "There must be a chain of command emphasis to determine who owns what, at what level, and who has to pay for improvement updates," said Richard Medrano, PEO-STRI project director.[12] The issue is further complicated by software changes. PEOC3T directed PMs to adjust all new contracts to ensure NET training products are produced in accordance with IAW Army Standards to allow greater efficiencies and reduction in the development effort created by sharing materials. However, some contracts will not be renewed for years, resulting in lost efficiencies. All NET products need to be coordinated with the designated proponent prior to release to the field. (4, no pg)

SECURITY CLEARANCE

MACOMs currently do not have HQDA guidance on the security level that must be maintained during training. For example, when units, or the institution, conduct individual training on either white boxes or purged ABCS systems not connected to the tactical Internet, should the training be secret? "Security classification is a roadblock and is not consistent throughout the army," Griffith said.[13] The MACOMs have also expressed concern over the physical security requirements for storing ABCS-related equipment and hard drives. In the past, secure communication devices were stored inside tactical vehicles that, in turn, were secured inside motor pools. Units, CTCs, and the TRADOC institutional training base indicate that declassifying hard drives requires extensive time and affects unit readiness. One alternative may be to provide a classified and unclassified hard drive for each system, a better purge program to clean hard drives, or racks for external storage in secure locations.

Another security issue is the training community's ability to interact with ABCS systems at the Secret level. Neither installation simulations facilities nor Combat Training Centers (CTCs) currently have the ability to operate at this level. Program Evaluation Office (PEO) Soldier and DAMO-RQ are co-hosting a working group to find technical solutions that will allow uncleared soldiers to send and receive combat-relevant information from a classified network. (4, no pg)

Current policy requires that all soldiers, DA civilians, and contractors who can access classified data in ABCS systems have secret security clearance. Many units are currently operating in violation of this policy. Currently, G-2 handles clearances for Army military personnel and DA civilians; DoD pays for contractor clearances. (4, no pg) "DoD must have an administrative portion of security clearances within the service, over services and international entities," observed Jack Stankiewicz, 78th Battle Projection Center coordinator. [14]

A NEED TO TRACK AND ASSIGN SOLDIERS TRAINED ON DIGITAL SYSTEMS

The Army currently has limited ability to track soldiers trained in digital systems and assign them to digital units. This forces units/installations to train new soldiers in addition to conducting sustainment, refresher, and delta training. With the ability to track and assign soldiers with digital skills, the Army can better manage digital soldiers to lessen the effect of turnover and reduce individual training. Personnel Duty Skill Identifiers are a short-term method of tracking soldiers with digital skills, but MACOMs currently cannot request those soldiers. (4, no pg) "The Army needs to create a training and utilization path for soldiers that are trained to ensure they remain with like units to keep from retraining others to fill vacant slots as those soldiers move to non digitized units," noted LTC Kanzenbach. [15]

Units who have not trained in the CCTT within the last 180 days must allot time to conduct initial or refresher CCTT system training. This training takes approximately eight hours to complete and includes a site orientation, manned module familiarization, combat-based instruction on operating the unit support workstations and the DIM, and an orientation exercise to familiarize participants with the CCTT features in preparation for unit training exercises. (6, pg 63)

Reducing the amount of materials distributed by manufacturers of systems continues to be a concern to unit and CCTT-support personnel. A key issue is distinguishing among these types of information: *nice to know, should know,* and *must know.* In regard to that issue, a lesson learned is that the manufacturers' developers, together with military subject matter experts, should carefully review materials to determine what information is truly vital in performing the assigned roles in the CCTT. Also, there is a need to review each piece of information, on its own merit, for inclusion in either the reference or distribution set of information. Developers tend to include all potentially useful information on the premise that if it is not needed; it can always be removed. The longer this information remains available, the more it is perceived as necessary, and it becomes increasingly difficult to remove. (1, pg 64)

Three aspects of L-V-C pose particular challenges for data synchronization:

1. Scale: Systems used in simulations must scale to at least several thousand access nodes per division. Each access node both reads data from the systems and writes updates to the systems. The systems must also scale geographically with different nodes that are located hundreds or thousands of miles apart.

2. Continuous access: Systems used in simulations are mission-critical and must provide continuous read/write access to the information it stores.

3. Intermittent connectivity: The information systems used for simulations must also be used for operations and must cope with intermittent connectivity. Nodes may not be able to communicate at certain times due to power constraints, the risk of communications being detected, equipment damage, or enemy interference with communication. The need for continuous access and intermittent connectivity while using the system for both simulations and operations make constructing a data system for this environment challenging. In particular, although it is well understood how to scale traditional centralized databases, they cannot meet these system requirements. (3, pg 1)

A central-master topology has a single "master database" and a set of replicas that contain copies of all or part of the data in the master. Application programs, called clients, may read and write data from the master database or any replica However, updates made at a replica are considered tentative until the central master has committed them. Once the central master has committed an update, it is responsible for transmitting that update to all the replicas. (3, pg 1–2)

The advantage of the central-master topology is its simplicity, which takes three forms. First, there is no need for clients to determine where to send updates—all updates go to the central master. Second, there is no concern about data conflicts among servers—conflicts can be detected, and resolved, at the central master alone. Third, stale reads do not occur because the central master is the sole source of authoritative data. The disadvantages of this topology, however, are contention for access to the central master, causing read and write delays; a potential fragility due to having a single point of failure; and the inability of clients to operate when disconnected from the central master. (3, pg 3)

The problem of maintaining consistency among these databases—the data synchronization problem—may be relatively severe for ABCS for the three reasons identified above. First, ABCS must scale to thousands of nodes, where each node both reads data from the system and writes updates to the system. Second, ABCS is mission-critical so it must provide continuous access to its data. Third, the system must cope with problems of intermittent connectivity in the network.

Although asynchronous replicated databases are designed to address these challenges, the two fundamental problems in asynchronous systems, stale reads and write conflicts, can arise. (3, pg 6) "We must have data consistency in building data bases," noted Stephen Whitson, senior software systems engineer, Battlefield Systems, MITRE.[16]

Stale reads occur when one node updates a database value, but other nodes read the old value before the new value reaches them. Conflicts occur when two different nodes update the same value at about the same time. When the asynchronous propagation of these writes occurs, the system must discard one of the conflicting writes and keep the other.

In the asynchronous environment of military conflicts, the two problems have potentially serious consequences. Stale reads can cause users to make decisions based on incorrect data, and conflicting writes can cause the system to lose important inputs. Furthermore, the combination of these two problems can cause errors to ripple through the system when database updates are made based on stale reads or on reads of writes that are later discarded due to conflicts. (3, pg 1–2)

V. WHAT CHANGES ARE NEEDED TO ENSURE M&S SUCCESS?

With a declining defense budget in a highly competitive resource environment, the first thing about models and simulations (M&S) that must change is a prevalent attitude toward them. As LTC Jim Kanzenbach, Chief Warrior-T, Fort Hood, observed in an interview on October 31, 2002, “The biggest problem we have is ‘that’s the way we have always done it’ (TTWWHADI).[17] We must get over the comfortable way and accept change.”

The National Military Strategy (NMS) requires the Armed Forces to help shape the international environment and respond to a full spectrum of potential crises while preparing for an uncertain future. To support this strategy in the face of weapons of mass destruction (WMD), terrorism, and other asymmetrical threats, the United States must:

1. Maintain forces of sufficient size, depth, flexibility, and combat power to defend the U.S. homeland.

2. Maintain an effective overseas presence.

3. Conduct a wide range of concurrent engagement activities and smaller-scale contingencies, including peace operations.

4. Conduct decisive campaigns against multiple adversaries, simultaneously, overseas.

Live, Virtual, Constructive simulations (L-V-C) must support joint, multinational, and interagency training and exercises and focus on commanders, staffs, and component forces, including joint task forces (JTFs). Joint training activities use the Joint Training System Support Team (JTSST), Deployable Training Team (DTT), Joint Distributed Learning Center (JDLC), and centralized training such as the UNIFIED ENDEAVOR (UE) exercises. The L-V-C must interoperate with and support these joint-training instruments.

UNIFYING EFFORTS

L-V-C must include interagency aspects in order to create realistic conditions in which commanders make decisions. The U.S. military will rarely respond to a crisis alone. Contemporary challenges require the National Command Authority to respond with a mix of political, economic, humanitarian, and military resources. Leaders are faced with the challenge of unifying efforts to ensure a cohesive U.S. government response. This challenge suggests the need for a single training and doctrine system. However, U.S. government agencies outside of the DoD are not subject to DoD training standards and practices. These agencies need to be integrated into military exercises to practice unity of effort through consensus, not through unity of command.

L-V-C must also support multinational operations. Fully integrated multinational operations, including the command and control of multinational forces, require close communication and cooperation among all parties and consideration of varied cultural frames of reference. The purpose of training will be to ensure an effective multinational operating environment, and the L-V-C must approximate this environment. L-V-C exercises will support the following Universal Joint Task List (UJTL) tasks: 1. ST 8.2—Provide Support to Allies, Regional Governments, International Organizations or Groups, and 2. ST 8.3—Obtain Support for U.S. Forces and Interests; OP 5.7—Coordinate and Integrate Joint/Multinational and Interagency Support; and JP 3-16, "Joint Doctrine for Multinational Operations." (8, page 27–28)

SECURITY

The issue of security must also be addressed. This includes M&S security status: Who needs security clearance and at what level? The following must be accomplished:

1. Army G-2:
   a. Clarify relevant physical security guidance resulting from Army Battle Command System (ABCS)-specific equipment.
   b. Support increased security clearance requirements for digital units, combat training centers (CTCs), Training and Doctrine Command (TRADOC) Institution, and Army personnel and Department of the Army Civilians (DACs).
   c. Develop Headquarters Department of the Army (HQDA) guidance for Major Commands (MACOMs) to address immediate security clearance shortfalls.
2. Army G-3:
   a. Determine and validate the need for the Army to conduct training at the secret level.
   b. Determine and validate resulting, critical, security requirements.
3. Army G-6:
   a. Develop tactical Internet accreditation guidance for the MACOMs to use in developing implementation plans.
   b. Develop overarching ABCS operational security guidance for the MACOMs to use in developing implementation plans.
4. MACOMs:
   a. Determine current security-clearance shortfalls that could impede operations at the secret level at the home station or deployed, at the CTCs, and within the TRADOC.
   b. Identify all military personnel, DACs, and contractors who require secret clearances and submit clearance requests.

TRACKING AND ASSIGNING SOLDIERS WITH DIGITAL SKILLS

Once soldiers are trained, they must be tracked and assigned them to related positions. A personnel tracking system managed by PERSCOM by assigning Personnel Duty Skill Identifiers should be designated to track soldiers with digital skills. PERSCOM needs to work with the installation to identify soldiers assigned to units and stabilize them, whenever possible, for the duration of the transformation. PERSCOM needs to continue to identify and track soldiers who have acquired the digital skills. Soldiers already filling digital positions and/or who have less than 24 months time on station will not be considered for reassignment. (11, no pg)

PROCUREMENT AND BUDGET ISSUES

Military procurement procedures must be changed. It is essential to "design" Future Combat Systems (FCS) in simulation before ever pouring metal in the manufacturing process. (5, no pg) While the Army will always need to focus on training, both for its missions and for the operation of new technologies, a fundamental shift in thinking needs to occur as the Army faces a mounting barrage of high technology equipment.

Only after the best possible system design has been procured should the focus shift to training. Relying on training to overcome poor design will always result in a suboptimal situation. No matter how well-trained soldiers are, they will be unable to perform to their best potentials with poorly designed information systems. The best way to leverage information technologies successfully is to design them to provide the best throughput to human operators. Once that is achieved (and only then), the focus should shift to training. (9, page 60)

The Army needs an integrated, innovative L-V-C environment where all training devices, simulations, and simulators can operate. All devices, simulations, and simulators must be interoperable within the legacy, interim, and objective forces and Joint, Interagency, and Multi-national (JIM) forces. (8, page ii) Future combat operations will probably involve a mix of objective force units, interim units, and legacy force units. They will be equipped with an array of battle command systems that vary in capability and interoperability. Moreover, the Army will operate in a JIM and Special Operations Forces (SOF) environment that will also include a wide range of battle command and training capabilities.

An important role of the L-V-C is to provide a means for ensuring the training interoperability of these disparate forces. Future training events will become increasingly joint in scope and purpose. Army CTCs will have joint training objectives and events incorporated into most rotations, and some rotations will be conducted as part of a larger joint exercise involving other services' forces and training areas. The L-V-C environment will be the primary means of synchronizing these various components to present a single, coherent operating picture to trainees. (8, page 13)

The budgeting conventions of the Department of Defense and the Congress have almost always involved purchasing simulators by reducing OPTEMPO, seeking both to reduce overall expenditures and to offset the cost of procurement. The word "simulation" then bears the burden of two generations of short-sighted service programming, during which the Office of the Secretary of Defense (OSD) and the Congress were taught that a simulator, especially an expensive aviation simulator, should be funded only when test data could be produced to demonstrate that the device would "pay for itself" by being demonstrably cheaper than actual equipment used for training, and at least as effective. (13, pg I–4)

Two streams of events are now converging. Reductions in the funds available for OPTEMPO (i.e., combat training in the field), reductions in the number and size of ranges available for such training, coupled with concern for noise and environmental factors, all combine to reduce the opportunities for live simulation and combat training with actual equipment under realistic conditions. However, major advances in computer capability and in high-capacity global communications-much of it the result of commercial interest-have facilitated the growth of constructive and virtual simulation. (13, pg I-7)

Building a system that will train every warfighter in the U.S. Army for every possible contingency is an intractable problem. However, by making certain assumptions, and by setting bounds and focal points, a cost-efficient system can be developed to meet the needs of the C4I training community. The primary focus will be on the interaction of humans using the tactical C4I systems as opposed to simulated representation of commanders and staffs (Virtual Command Posts). (12, pg 8) Understanding the simulation live cycle/exercise cycle will help target specific tasks and maximize the effectiveness of the overall training package. Furthermore, to allow the simulation/live exercise cycle to be run, a synthetic representation of the training range is also required. As the system is fielded, the number and location of databases will need to increase. (12, pg 16)

Many lessons learned in M&S development for design/manufacturing will be beneficial towards developing tests of equipment. They have already been implemented in the technical testing world at the Virtual Proving Ground at Aberdeen Proving Grounds. By including logisticians as part of the collaborative environment, sustainability can be incorporated into the Objective Force as a design parameter rather than waiting until the system is fielded to determine how it will be sustained. Lessons learned during M&S development should allow commanders and staff tools to allow "analytically" based planning and rehearsal tools. (10, no pg)

INTEROPERABILITY BETWEEN M&S AND TACTICAL COMMAND

The tactical command and control (C2) world is changing the implementation of interoperability. Technological advances and new requirements are driving these changes. The changes make it difficult to keep the interface between the M&S and C2 worlds current. A common infrastructure that provides interoperability between the M&S and tactical C2 worlds needs to be developed to insulate M&S from any disorder in tactical C2 hardware and software protocols. A standard means of communicating information between M&S and interface devices could be developed to allow the same interface software and hardware to be used for a variety of M&S and C2 combinations. The interface would contain specialized hardware and software to receive tactical messages, separate them, interpret the contents, and put pertinent information into standardized structures that could then be passed to M&S in a standardized form. The reverse process would occur for messages passing from M&S to tactical command and control equipment. (11, page 7) To provide interoperability and produce a common operating picture, it is imperative to develop a common operational platform. This includes a common operating system (OS), standards, protocols, and user interface. (8, page ii)

Within the military command and control communities, standardization programs have been evolving in response to operational and budgetary issues very similar to those encountered in the simulation community. As computerized systems were developed for command, control, communications, and intelligence, a variety of different hardware architectures, data representations, and network standards created an environment in which each system was electronically isolated from the others around it. Each was unable to exchange data except through direct human intervention. Standardization first occurred within each service and is now extending across the services and into allied systems. (16, pg 2)

Remoting simulations, where multiple simulations at different geographical locations could be made to interact, allow soldiers to train with other soldiers while remaining at their home stations. The second part of the equation was to link dissimilar simulations so that systems that were designed for a particular representation (for example, specific weapon systems, logistics, threat, command and control) or for a particular service (Army, Air Force, Navy, or Marine Corps) could interact. Linking allowed the specialized models and simulators in the Army and Joint services to conduct more realistic operations and war-gaming. (8, pg 9) The DIS program was designed to link separated, autonomous simulations (without the requirement for a central common computer) that could interact and fully communicate with each other. The DIS was initially an extension of SIMNET, but later was extended to include all types of virtual, constructive, and live simulation. The DIS has expanded into an extension of the concept called high-level architecture (HLA). The HLA will be used for future developmental simulators

To create simulation interoperability the HLA uses the Runtime Infrastructure (RTI), allowing applications on a variety of host computers to access a standard set of services for exchanging data with other applications connected to it. Extending this bridging technique will allow any simulation to access any C4I system through standard RTI services. The Defense Modeling and Simulation Office (DMSO) is developing the Modular Reconfigurable C4I Interface (MRCI) to serve as a common gateway application to C4I systems architectures. It will operate as an RTI member and support the exchange of information between compliant simulations and C4I systems. However, the design calls for the integration of simulation-specific software into the real C4I systems, which is a significant limitation to the ability to implement and scale. (16, pg 8)

Replacing the MRCI with a more general, non-intrusive gateway that joins the simulation and the C4I standard protocols is essential. New simulations will not be required to understand C4I-specific services, but rather, a single interface will provide the bridging mechanism for connecting to all RTI-compliant simulations. Similarly, the Joint Simulation Systems (JSIMS) project proposes a single architecture for all command staff trainers. Within this architecture there exists a component which specifically models the physical performance of pieces of equipment. This component also supports the surrogate representation (ghosting) of real-world equipment. This capability is specifically targeted to providing a simulation the capability to communicate with internal models without having to differentiate between real equipment and simulated equipment. (16, pg 9)

Though the military is going to great lengths to join M&S and command, control, communication, computers, and intelligence (C4I) systems, in the future, simulation capability may be built directly into real-world C4I systems. The current trend toward providing decision-support capabilities to commanders through their C4I systems is already placing simulation-like capabilities in their combat systems. A joint M&S-C4I architecture could allow the creation of a system from the components needed for a mission (real or training), whether the components come from a simulation source or tactical source. Creating cross-domain architecture will require a joint requirements-analysis process to identify the commonality between M&S and C4I systems. The analysis must be followed by a requirements alignment in which similar, but not identical, requirements are matched and a system designed to meet both M&S and C4I requirements or modify them into a common requirement. From this process, a common M&S-C4I architecture can be developed. The architecture must accommodate both M&S- and C4I-specific requirements to serve both communities. Finally, the internal and external interfaces, be they M&S or C4I, must be defined. (6, pg 10)

Effectiveness and cost are two issues that dominate the choice between using a simulator for training and using actual equipment: the effectiveness and the cost of using the simulator compared to the effectiveness and cost of using the actual equipment. Simulations allow repeatability, 24 X 7 operations, wear and tear on the platform, and training in a crawl-walk-run mode. Effectiveness means the level of performance achieved by use of the simulator to obtain the skills specified as needed to operate the actual equipment or, in the case of a maintenance training simulator, to maintain complex equipment. Examinations of cost should address all costs, on a life cycle basis; some studies examine only the procurement costs or the operating costs. (13, pg III–1)

Technology is available to effectively train maneuver tasks in a virtual simulations environment at a fraction of the cost of live training. Simulations are better than ever, graphics are more realistic, vehicles more closely replicate the actual vehicles, and all the "gee whiz" features are there. (15, pg 1)

MAINTAINING FOCUS

We must direct our attention to three goals:

1. Be Efficient Today.
2. Focus on the Future.
3. Think and be Joint.

Implementing a common vision and supporting strategy will set the stage for success: Highly competent people using world-class M&S that meet the needs of the Total Force across the full spectrum of operations. (1, pg iv)

1. BE EFFICIENT TODAY.
    a. Eliminate Duplication. While many missions require tailored M&S applications, it is no longer efficient to develop a unique M&S for every need.. All users must work through the Requirements Integration and Approval (RIA) process to ensure that their requirements are integrated.
    b. Leverage Opportunities for Reuse. All M&S managers, developers, and users must plan for reuse in the broadest sense. The Army's M&S standards provide a starting point for all developments. Organizations must also look beyond the Army for opportunities to leverage developments from other service, joint, and Office of the Secretary of Defense (OSD) programs. To properly apply

available resources to achieve the vision, all unique requirements aspects must be carefully balanced with the potential benefits of reuse.

c. Share Information. Harnessing the power of information technology will be as important for the Institutional Army as it is for the Operational Force. The key to successful integration and leveraging is to know the technology that is available. All organizations must support the Army's efforts to collect and share information on M&S activities.

2. FOCUS ON THE FUTURE.

The Objective Force is about the future. M&S systems must be developed to help us prepare for the future while sustaining our legacy systems at a minimal level. It is essential to ensure the availability of the M&S tools necessary to examine issues that shape the future. (1, page 5–2) To fully realize the benefits of M&S, managers must follow the example of the commercial industry by adjusting processes and building the infrastructure to support a long-term strategy, not just short-term benefits. The Army has a broad range of programs developing next-generation M&S across domains. These programs will replace a myriad of legacy systems. While many people would like to fix the problems of older systems, it is no longer affordable to fix every fault in these systems. Users and program managers must ensure that systems planned for replacement receive only the maintenance that is necessary.

3. THINK AND BE JOINT.

Today the Army operates in a joint environment. Users and developers must ensure that the requirements for future M&S cover the full spectrum of operations and capture the capabilities of our operational partners. It is also essential that the Army be prepared to describe its capabilities to others and support requests for information. Currently, several major efforts are under way to develop M&S for joint and service use. The Army must support these efforts and be prepared to use M&S to maintain credibility and relevance in the joint and OSD communities

Word Count 10,254

ENDNOTES

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